Continuous Emissions Monitoring Systems & Monitoring Options

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Glossary

- CEMS;

  A “Continuous Emissions Monitoring System” is all of the equipment required for monitoring under part 75 that is used to sample, analyze, measure, and provide a permanent record of emissions in the appropriate reporting format. (see official definition in §72.2)

Part 1 Overview

- CEMS
  - Monitoring Methodologies
  - General Monitoring Components
  - Alternatives to CEMS

Monitoring Requirements - Subpart H Monitoring

- NO_x Mass Emissions (lb/hr)

- Heat Input (mmBtu/hr)
  - Required if unit monitors NO_x Emission Rate and Heat Input Rate to determine NO_x Mass Emissions, or
  - If required by State Rule, or
  - If the unit is subject to the requirements of 40 CFR 97 (§126 units)

Monitoring Options for Determining NO_x Mass Emissions

- NO_x Concentration (ppm) & Stack Flow Rate (scfh)
- NO_x Emission Rate (lb/mmBtu) & Heat Input Rate (mmBtu/hr)
- Low Mass Emissions Methodology

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NO_x Emission Rate & Heat Input Rate Monitoring Options

- NO_x Emission Rate
  - NO_x-Diluent CEMS, or
  - Part 75, Appendix E (for gas or oil fired peaking units)

- Heat Input Rate
  - Stack Flow & Diluent (%CO2 or O2) CEMS, or
  - Fuel flow monitoring via Part 75, Appendix D

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NO_x-Diluent CEMS

- Two components
  - NO_x Concentration Analyzer &
  - CO_2 or O_2 Concentration Analyzer as the Diluent

- Part 75, Appendix F § 3, provides the equations that are used to compute NO_x emission rate (lb/mmBtu) given:
  - » NO_x concentration
  - » CO_2 or O_2 concentration
  - » F-factor for the fuel combusted

Heat Input Rate from Stack Flow and Diluent System

- Components for a Stack Flow-Diluent Heat Input System
  - Stack Flow Monitor &
  - CO_2 or O_2 Concentration Analyzer as the Diluent

- Part 75, Appendix F § 5, provides the equations that are used to compute the heat input rate (mmBtu/hr) given:
  - » Volumetric Stack flow
  - » CO_2 or O_2 concentration
  - » F-factor for the fuel combusted

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LME Monitoring Option for Determining NO_x Mass Emissions

- Low Mass Emissions Excepted Methodology
  - Default NO_x Emission Rate or Fuel-and-unit specific NO_x Emission Rate
  - Default Heat Input Rate or Long Term Fuel Flow

CEMS and Monitoring Options

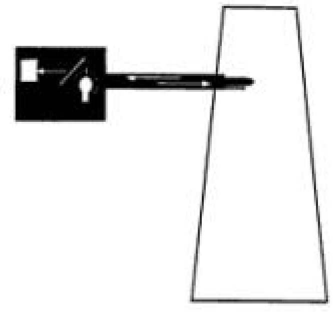
CEMS	Monitoring Options	Data Collection
➢ NO_x-Diluent CEMS (NO_x monitor & CO_2 or O2 monitor, for NO_x emission rate) ➢ NO_x concentration system ➢ Stack volumetric flow monitoring systems	➢ Part 75, Appendix D fuel flow monitoring (Gas & Oil units only) ➢ Part 75, Appendix E NO_x Emissions Estimation (Gas & Oil Peaking units only)	Data Acquisition and Handling System (DAHS) required as part of the monitoring system.
	➢ Low Mass Emissions Unit Methodology (Gas & Oil units only)	No DAHS required

Types of CEMS

- In-situ (Wet Basis measurement in the stack)
  - Point
  - Path
- Straight Extractive (Wet or Dry Basis Measurement)
  - Hot Wet - Wet Basis
  - Cool Dry with condenser near the CEMS Shelter - Dry Basis
  - Cool Dry with condenser at the probe - Dry Basis
- Dilution Extractive (Wet Basis Measurement)
  - In Stack Dilution
  - Out of Stack Dilution

In-Situ CEMS

- Point
  - Electro-optical, or
  - Electrochemical sensor
  - Measurement over short distant (~cm)
- Path
  - Light or sound is transmitted across the stack
  - The interaction with the stack gas is related back to a gas characteristic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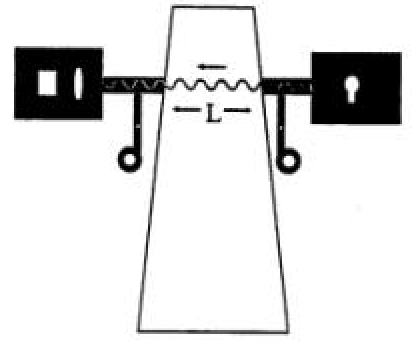

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In-Situ CEMS

- Typical Applications:
  - Opacity Measurement
    - » Path - Light
  - Stack Flow
    - » Point - Differential Pressure (s-type Pitot)
    - » Path - Ultra-sonic (sound waves)

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In-Situ CEMS

- Advantages
  - Lower cost
  - Compact
  - No CEMS Shelter
- Disadvantages
  - All analytical components on the stack
    - More difficult to maintain and quality assure
    - Analytical components exposed to harsh stack conditions
  - Many In-Situ CEMS do not accept calibration gas for calibration

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Extractive Systems

- Representative sample of the flue gas is removed from the stack, transported to a CEMS shelter and analyzed
- Components of an extractive system
  - Probe
  - Sample lines
  - Filters
  - Moisture removal system
  - Pump
  - Analyzer
- Advantages
  - Easy analyzer access for maintenance and adjustments
  - CEMS shelter provides for good instrument life
  - Calibration with gaseous standards possible

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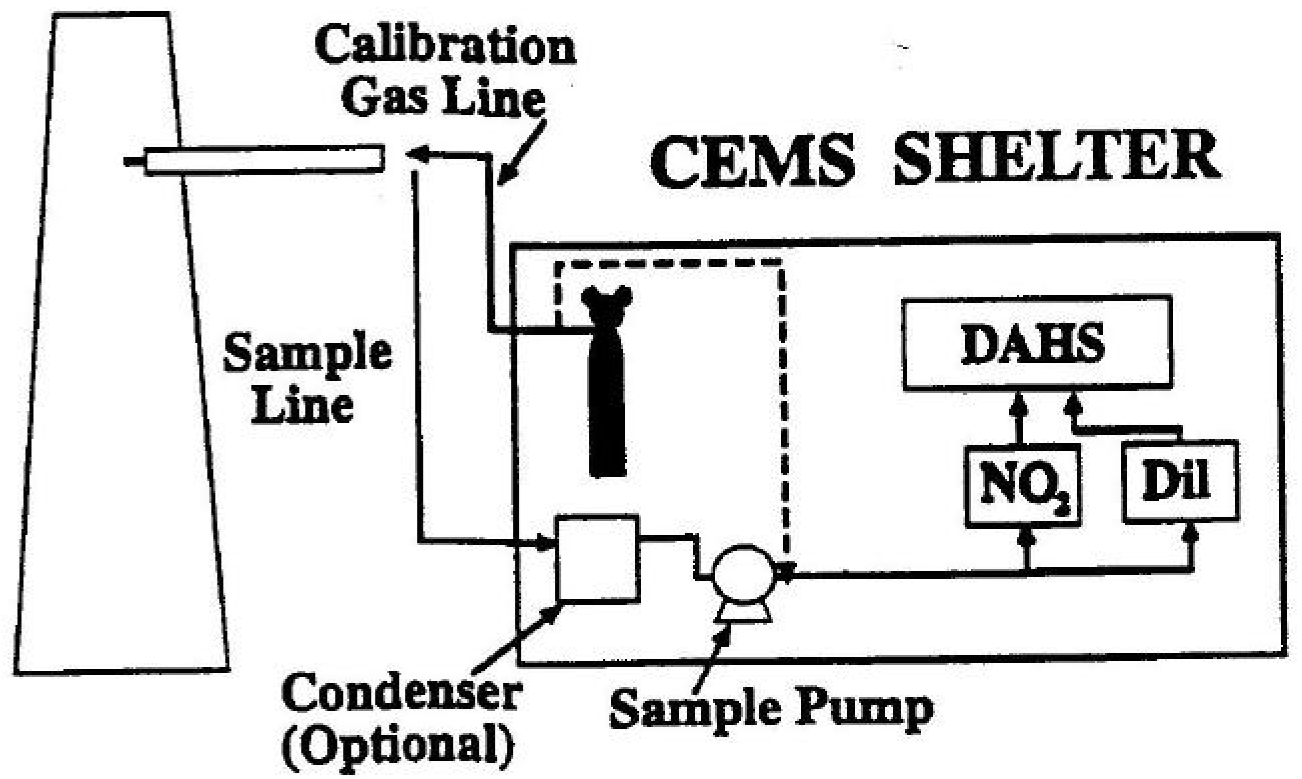
Conventional Extractive CEMS



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Hot Wet Extractive CEMS

- No condenser so moisture remains in the system throughout the sampling and measurement process
  - Heated sample line, pump and analytical chamber required to keep the wet sample above its dew-point
  - Sample is analyzed hot and wet

- Analyzers must be insensitive to sample moisture content

Hot Wet Extractive CEMS

- Advantage:
  - Water soluble gases including some VOCs can be measured without potential losses in the condenser system

- Disadvantage:
  - Heated line, pump, and analytical chamber are critical to system performance. A failure can result in corrosion, plugging, and damage to the system

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Cool Dry Extractive CEMS

- Flue gas is collected and passed through a condenser to remove moisture prior to analysis

- Two Options
  - Conditioning at CEMS Shelter
    - » Heated sample line required to keep the wet sample above its dew-point until it reaches the condenser

  - Conditioning at the stack
    - » No heated line
    - » however maintenance is difficult since the conditioning components are on the stack

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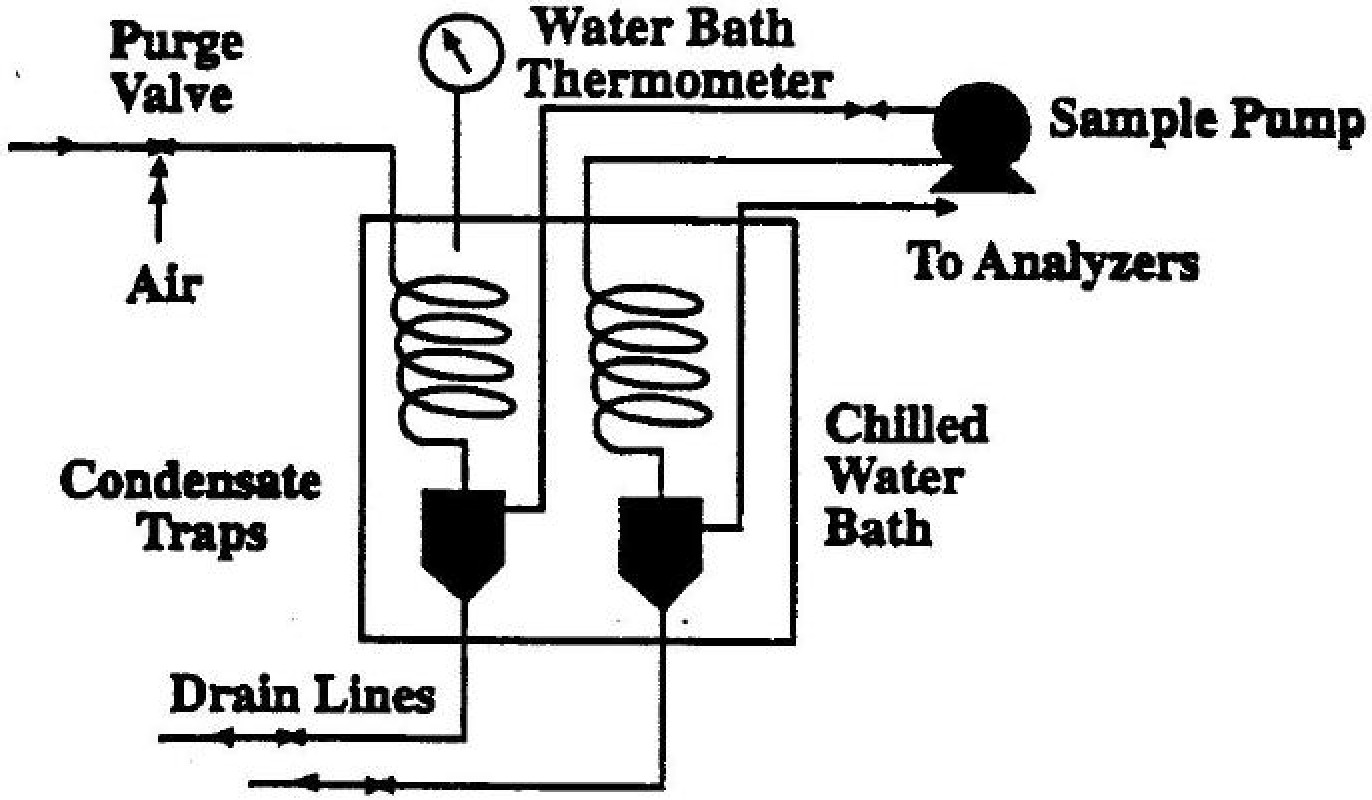
Basic CEMS Condenser



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Cool Dry Extractive CEMS

- Advantage:
  - greater flexibility in the choice of analyzers (ie, heated chamber not required)
  - Moisture interferences in the analytical components minimized
- Disadvantage:
  - Conditioning system maintenance required
  - Possible low bias due to scrubbing of pollutant from sample in the condenser
    - » May lead to failed RATA tests or Bias test and necessitate a BAF
    - » Care required to minimize losses of analyte in the condensate
  - Results may need to be adjusted to a wet basis for calculations

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Dilution Extractive CEMS (wet basis)

- Flue gas is diluted with clean dry air to lower the dew-point of the sample
  - Eliminates the need for
    - » Heated sample lines
    - » Moisture removal system
- Dilution ratio is controlled by creating sonic flow across a critical orifice
  - Sonic flow of sample is maintained by achieving a set pressure drop across the critical orifice.
  - Sonic flow also depends upon
    - » Molecular Weight of the sample
    - » Pressure
    - » Temperature

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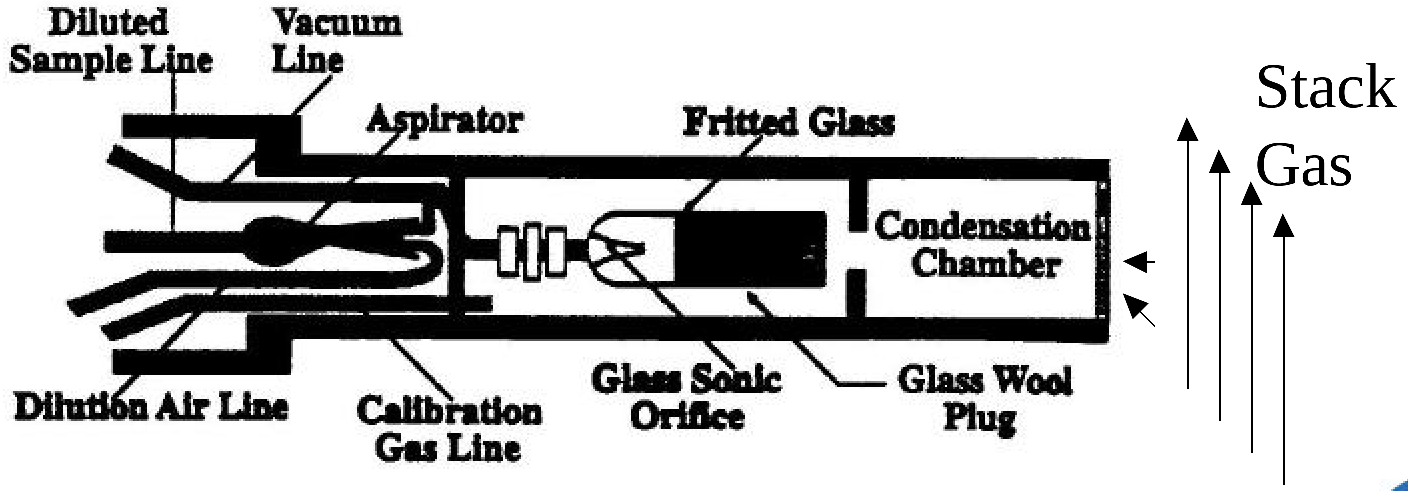
In Stack Dilution (dilution probe)

- Critical Orifice is in the probe
- Sample Temperature is Stack Temperature
- Quicker response than out of stack dilution
- No temperature controls to maintain



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Out of Stack Dilution (separate dilution unit)

- Critical Orifice is separate from the probe and outside of the stack
- Temperature must be controlled by heating
- Slower response
- Easier to replace Critical Orifice

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Dilution Extractive CEMS (wet basis)

- Advantage:
  - No moisture transport/removal issues
    - » No loss of sample due to moisture removal
    - » No need for heated sample line after the sample is diluted
- Disadvantage:
  - Dilution Probe effects may bias measurement
    - » Effects for Molecular Weight can be minimized by calibrating the system with protocol gases which possess a MW representative of the flue gas
    - » Usually highly dependent upon the CO_2 concentration
    - » Bias can be both positive and negative

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Gas Analysis and Measurement Principles

- Common Analytical NO_x Measurement Techniques
  - Chemiluminescence (NO)
  - Differential Ultraviolet Absorption (NO_2)

- Diluent Techniques
  - CO_2
    - » Non-Dispersive Infrared (NDIR)
    - » Gas filter correlation (GFC)
  - O_2
    - » Electrocatalytic
    - » Micro Electrochemical Fuel Cell

Monitoring Location Specifications for Pollutant and Diluent Gas Monitors

- Install system at a location where the measurements will be representative of total emissions for the unit (§3.1 PS2)
- System must be able to pass a RATA
- Point Monitors must measure
  - At a point within the centroid of the stack, or
  - No less than 1.0 meter from the stack wall

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Monitoring Location Specifications for Pollutant and Diluent Gas Monitors

- Path Monitors must measure
  - Within the inner area bounded by a line 1.0 meter from the stack wall, or
  - So that 70.0% of the path is within the inner 50.0% of the cross sectional area, or
  - Such that the path crosses through the centroid

Stack Volumetric Flow Rate Monitoring

- Differential Pressure
  - S-Type Pitot
  - Annubar
- Acoustic Sensing
  - Ultrasonic
  - Audible Sensor
- Heat Transfer Sensing
  - Heat loss from a heated body to the flue

Monitoring Location Specifications for Stack Flow Monitors

- A flow monitor location is acceptable if either
  - the location satisfies the minimum siting criteria of method 1
    - » Locate 8 stack diameters downstream & 2 upstream of any disturbance
  - the results of a flow study are acceptable
- Also the flow monitor must be able to pass the required performance tests

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Alternatives to CEMS

Alternatives to Using CEMS

- CEMS are required except for cases that qualify to use the following options:
  - Appendix D - Heat Input Rate from Fuel Flow Meters
  - Appendix E - NO_x Emission Rate Estimation Procedures
  - LME - Default NO_x Rate for Low Mass Emission Units

Part 75, Appendix D

- Applicability
  - May be used in lieu of flow monitoring systems for the purpose of determining the hourly heat input rate
  - Gas and Oil fired units only
- Heat input rate (mmBtu/hr) is determined from the:
  - Fuel Flow Rate (fuel flowmeter), and
  - Gross Calorific Value (GCV) of the fuel

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Part 75, Appendix D (Fuel Flowmeters)

- Fuel Flowmeters
  - Must meet the fuel flowmeter accuracy specification for initial certification (App D § 2.1.5)
  - Visual inspection of orifice, nozzle, and venturi meters every 3 years
  - Must pass a fuel flowmeter accuracy test at least once every four QA operating quarters (App D § 2.1.6)
  - Fuel flowmeter accuracy $\leq$ 2% of the flowmeter's upper range value

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Part 75, Appendix D (Fuel Flowmeters)

- Types of Fuel Flowmeters
  - Orifice Plate
  - Nozzle
  - Venturi
  - Coriolis
  - Others that meet the applicable specifications

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Appendix D
Basic GCV Fuel Sampling Options

- Oil Sampling
  - Flow proportional/weekly composite
  - Daily manual sampling
  - Storage tank sampling (after each addition)
  - As delivered (sample from delivery vessel)
- Gas Sampling
  - Monthly Samples (pipeline natural gas, or natural gas, or any gaseous fuel having demonstrated a “low GCV variability”)
  - Daily or Hourly Samples (any gaseous fuel not having a “low GCV variability”)
  - Lot sampling (upon receipt of each lot or shipment)

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Part 75, Appendix E

- May be used in lieu of a NO_x-diluent CEMS for determining hourly NO_x emission rate (lb/mmBtu)
- Applicable only to Gas and Oil-Fired Peaking Units

Part 75, Appendix E

- Peaking unit (§ 72.2 - Definitions)
  - An average capacity factor of no more than 10.0% during the previous three calendar years and
  - A capacity factor of no more than 20.0% in each of those three calendar years
  - Ozone season only reporters can qualify on an ozone season only basis §75.74(c)(11)
- Initial qualification for peaking status by
  - Three years (or ozone season) of historical capacity factor data, or
  - For newer or new units, a combination of all historical capacity factor data available and projected capacity factor information

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Part 75, Appendix E

- For units that make a change in capacity factor may qualify by:
  - Collecting three calendar years of data following the change to meet the historical capacity factor specification, or
  - Collect one calendar year of data following the change showing a capacity factor of less than 10.0% and provide a statement that the change is considered permanent

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Part 75, Appendix E

- Units that hold peaking status must continue to meet both the 10% three year and 20% single year (or ozone season) criteria to retain peaking status
- If a unit fails to meet the criteria it must install & certify a NO_x CEM by January 1 of the year after the year for which the criteria are not met
- A unit may then re-qualify only by providing three new years (or ozone seasons) of qualifying capacity factor data

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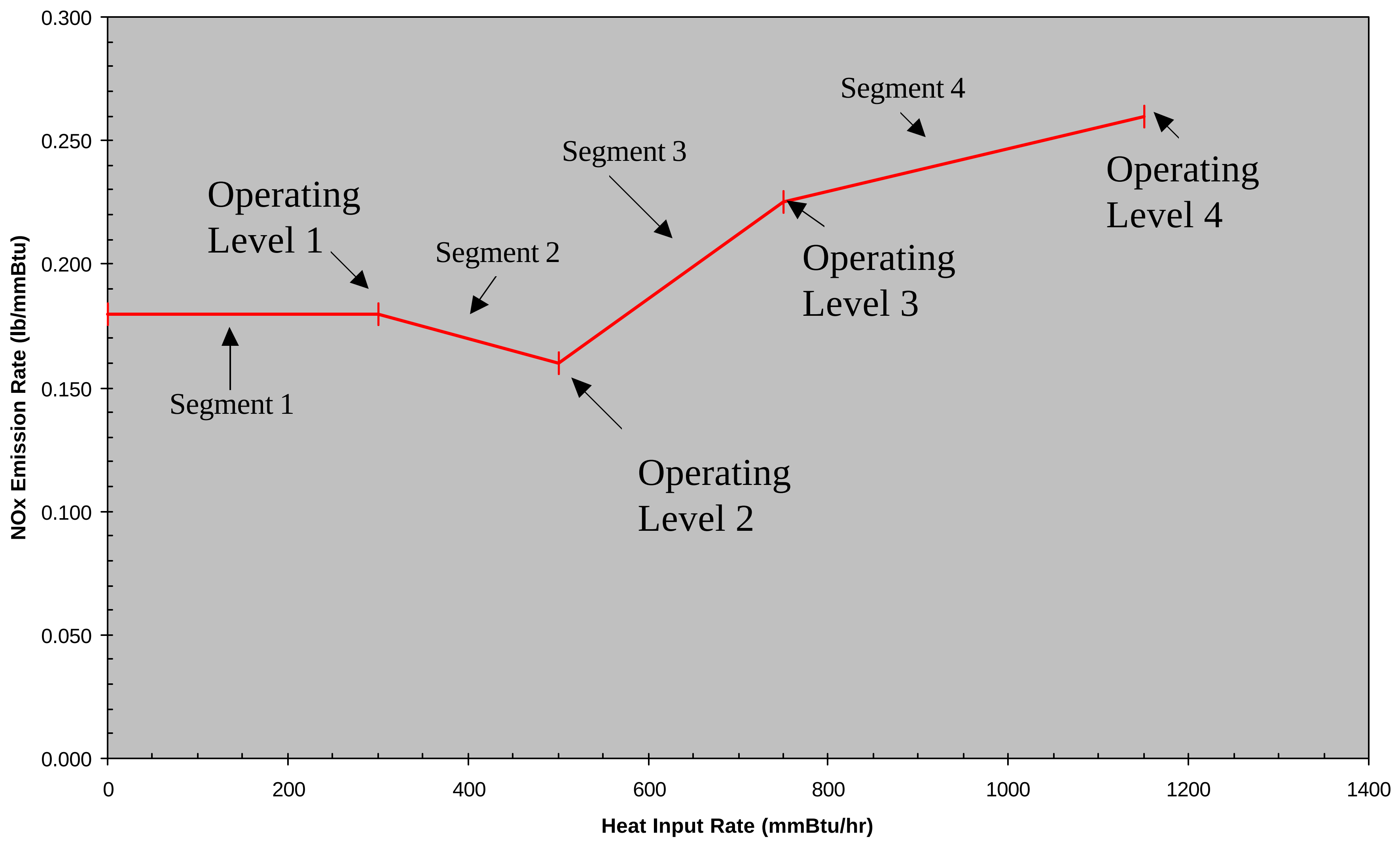
Part 75, Appendix E

- The average NO_x emission rate (lb/mmBtu) is determined from
  - Periodic fuel specific NO_x emission rate testing at four, equally spaced load levels
    - » Boilers
      - Method 7E for NO_x
      - Method 3A for the diluent
    - » Stationary gas turbines
      - Method 20 for NO_x
      - Method 3A for the diluent

Part 75, Appendix E

- Plot the NO_x Emission Rate vs. Heat Input Rate
- Use the graph of the baseline correlation results to determine the NO_x emission rate corresponding to the heat input rate for the hour
  - Linearly interpolate between reference points to the nearest 0.001 lb/mmBtu using heat input values rounded to the nearest 0.1 mmBtu/hr

NO_x Correlation Curve Segments



Low Mass Emissions Unit Methodology (§75.19)

- Procedure that may be used in lieu of CEMS or the excepted methods under App D and E for the purpose of determining hourly heat input and NO_x mass emissions
- Natural gas and fuel oil only
- NO_x emissions limitation
  - Year round reporting units: $NO_x \leq$ 50 tons/year
  - Ozone season only reporting units: $NO_x \leq$ 25 tons/control period

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Low Mass Emissions Unit Methodology

- Applicability:
  - Natural Gas and Fuel oil combusting units only
  - An initial demonstration that the unit emits no more than 50 tons of NO_x per year, or no more than 25 tons per control period ozone season only reporters
  - An annual demonstration that the unit emits no more than 50 tons of NO_x per year, or no more than 25 tons per control period ozone season only reporters
- This methodology relies on
  - Either a Default NO_x emission rate or a Fuel-and-Unit Specific NO_x emission rate, and
  - Either a Maximum Rated Hourly Heat Input for the unit or records of Long Term Fuel Flow

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LME - NO_x Emission Rate

- Default NO_x Emission Rate
  - Table LM-2 of §75.19(c)

Boiler Type	Fuel Type	NO_X Emission Rate (lb/mmBtu)
Turbine	Gas	0.7
Turbine	Oil	1.2
Boiler	Gas	1.5
Boiler	Oil	2

- Fuel-and-Unit Specific NO_x Emission Rate
  - Perform four load Appendix E testing
  - Use the highest NO_x emission rate from the testing multiplied by 1.15 or
  - 0.15 lb/mmBtu whichever is greater

LME - Heat Input Rate

- Maximum Rated Heat Input Method
  - §72.2 defines the Maximum Rated Heat Input as “a unit-specific maximum hourly heat input (mmBtu) which is the higher of the manufacturer’s maximum rated heat input or the highest observed hourly heat input”
  - Total Heat Input for the quarter is the product of the number of operating hours and the Maximum Rated Heat Input

$$HI_{qtr} = OPHrs_{qtr} \text{ x } MRHI$$

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LME - Heat Input Rate

- Long Term Fuel Flow Heat Input Method
  - Fuel Flow
    - » Qualified fuel billing records
    - » A fuel measurement standard listed in §75.19(c)(3)(ii)(B)(2), or
    - » A fuel flowmeter certified, maintained, and quality assured according to Part 75 Appendix D

LME - Heat Input Rate (LTFF Method)

- GCV
  - Part 75, Appendix D §2.2 and 2.3, or
  - Default GCV in Table LM-2
    - » Pipeline Natural Gas - 1050 Btu/scf
    - » Natural Gas - 1100 Btu/scf
    - » Residual Oil - 19,700 Btu/lb or 167,500 Btu/gal
    - » Diesel Fuel - 20,500 Btu/lb or 151,700 Btu/gal
- Total Heat Input is apportioned by load to each operating hour at the end of each reporting period
  - MDC has a module that helps in performing this task and generates EDR records for the electronic report (for single units only) - Contact Kim Nguyen

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End

Questions?